SAGE III on ISS
Lesson Grades 9-12

SAGE III: Making Measurements from the International Space Station

Purpose:
The students will gain a better understanding of the importance of using multiple data points when making observations over a long period of time. Students will also compare data collection outcomes when single or small data sets are collected versus a larger data set and longer collection periods are used.

Grade Level:
9-12 (This lesson can be adapted for use in middle school with additional guidance from the teacher.)

Estimated time for Completing Activity:
60-90 minute class period

Learning Outcomes:
- The student will analyze data sets of different sizes and draw conclusions as to how much data is needed to better understand a parameter over a defined period of time.
- The student will gain a better understanding of the need to collect as much good data as possible in order to better understand our Earth.
- The student will be able to better understand the size of a data set and how to best apply the measures of central tendency (mean, median, mode, and range)

Standards:

6-8 NGSS

MS-ESS3-5 Ask questions to clarify evidence of the factors that have caused the rise in global temperatures over the past century.

MS-ESS3-4 Construct an argument supported by evidence for how increases in human population and per-capita consumption of natural resources impact Earth's systems.

9-12 NGSS

HS-PS4-2 Evaluate questions about the advantages of using a digital transmission and storage of information.

HS-ETS1-1 Analyze a major global challenge to specify qualitative and quantitative criteria and constraints for solutions that account for societal needs and wants.

HS-ESS3-6 Use a computational representation to illustrate the relationships among Earth systems and how those relationships are being modified due to human activity.

Prerequisites:
- Understanding of the measures of central tendency (mean, median, mode, and range) as a type of data analysis.
- Understanding of what aerosols are and how they impact the light that is transmitted from the Sun to the Earth.

Vocabulary:

- Analyze – examine in detail to draw conclusions about an item or set of data
- Mean - an average of the data set in question (sum of the data divided by the number of individual data points)
- Median – the middle point in a set of numbers
- Mode – the number that appears the most often in a set of data, this can be easily found by putting all of the numbers in ascending order
- Range – the difference between the largest and smallest value in a set of data
- Average – *see mean*
- Measures of Central Tendency – the measures used to describe and analyze a set of data, this includes mean, median, and mode
- Aerosol – small liquid or solid particles dispersed in the atmosphere; large quantities are often regarded as pollutants in the form of haze and smoke
- Optical Depth – a measure of the reduction of light or energy transmitted through the atmosphere due to interactions with air, cloud or aerosol particles

Lesson Links:

SAGE III Education Page - http://sage.nasa.gov/SAGE3ISS/education.php
Launchpad SAGE Video - http://archive.org/download/NASA_Launchpad_SageIII_HD/NASA_Launchpad_SageIII_4x3.zip
Pinatubo 1- http://www.youtube.com/watch?v=SMe0VPQftsc
Pinatubo 2- http://www.youtube.com/watch?v=PvpBbiCG-7s
Pinatubo 3- http://www.youtube.com/watch?v=74QkHh45bjw

Background:

The Stratospheric Aerosol and Gas Experiment (SAGE) was launched aboard the Earth Radiation Budget Satellite (ERBS) in October 1984. During each sunrise and sunset encountered by the orbiting spacecraft, the instrument used the solar occultation technique to measure stratospheric aerosols, ozone, nitrogen dioxide, and water vapor.

Data from SAGE II, in conjunction with data from sister instruments SAM II and SAGE I, can be used to estimate long-term constituent trends and identify responses to episodic events such as volcanic eruptions. The data SAGE II collected was integral to confirming human-driven changes to ozone, and thus contributed to the 1987 Montreal Protocol that banned certain harmful chemicals. SAGE II also saw that ozone stopped decreasing in response to this action. Major results from SAGE II include illustrations of the stratospheric impact of the 1991 Mount Pinatubo eruption, identification of a negative global trend in lower stratospheric ozone during the 1980s, and quantitative verification of the positive water vapor feedback in current climate models.

The constituent record provided by SAGE II was continued and improved by its successor SAGE III-Meteor-3M, which was successfully launched onboard a Russian spacecraft on December 10, 2001, and will be further extended by SAGE III on ISS,

which is scheduled for launch in February 2016. Today, the SAGE technique is still the best for the job, and NASA scientists are preparing to send the third generation of the instrument into space. However, not just any spacecraft will do for SAGE III. Scientists have been keeping it safe, waiting for the day that it could go where no continuous Earth-observing instrument has gone before – the International Space Station (ISS). (http://sage.nasa.gov/)

The Lesson Procedure:

Be sure to write all of your answers on your own sheet of paper or in your science journal/binder.

Pre-Lesson Activity:

Have students write down an answer to the question, "What is an appropriate length of time to collect data to draw an accurate conclusion, and explain?" Once they have had time to write down their answer and explanation have them answer the question aloud so that they can hear other students' answers and explanations. After completing the lesson, students should answer this question again as one of their assessment questions.

Procedure:

1. Given the following set of data answer questions 1, and 2 below:

Date	Aerosol Value
1/6/1991	0.0015
1/7/1991	0.0014
1/13/1991	0.0014
1/14/1991	0.0014
2/20/1991	0.0014

2. Given the following set of data answer questions 3 through 6 below:

Date	Aerosol Value
7/8/1991	0.1300
7/13/1991	0.0942
7/14/1991	0.0933
8/10/1991	0.1990
8/21/1991	0.2180

3. Using the SAGEIIdata.xls file, locate the first and second data sets and highlight them.

4. Using excel plot the whole data set in a line connected scatter plot. This can also be done by hand if time allows in the classroom. Be sure to include a title and label your axes.

5. Finally answer question number 7 through 9 based on all that you have learned from the data and plots.

Questions:

1. Given the set of five data points from the table above, what observations can you make about the area in terms of its aerosol values?

a. Is it possible to make a short-term claim about the area, region and world based on this set of data? Why or why not?
b. If you apply the measures of central tendency (mean, median, and mode) are you able to make a more informed claim? Explain.
c. Given the second set of five data points, what observations can you make about this area in terms of its aerosol values?
d. Is it possible to make a long-term claim about the area based on this set of data? Why or why not?
e. Are these two data sets from the same location? Give an explanation that supports your claim.

2. Apply the measures of central tendency to this data set. What conclusions are you able to draw from your numbers? Explain how using this basic form of data analysis does or does not work. Would they be better with a different type of trend in the data? Give an example of this.
3. What could have caused aerosol values to change in this way?
4. How long were the base line values for the area affected?
5. Do you think that this is a normal occurrence? Explain why or why not.
6. Are these two data sets from the same location? Give an explanation that supports your claim.
7. After locating the two data sets in the larger set of data, how does this compare to your answers above.
8. Using the information in the data, can you identify the event that this data points out? Explain the process that you went through to determine the event.

Video Connection:

NASA Launchpad: SAGE III Goes to the ISS (9-12)
http://youtu.be/EKZVD3pqhGw

Extension Questions:

1. Using figures 1 and 2 from below, explain how they complement or criticize the line plot(s) that you created above. The first two plots should resemble the plot that you generated in the first part of the lesson.
2. Looking at the length of time that the event impacted the globe, what does this say about determining a base line in aerosol values for the equatorial region of the Earth?
3. Knowing that aerosols impact the amount of light that reaches the earth, what other natural disasters or events impact the amount of aerosols in the atmosphere? Are there any anthropogenic activities that impact this value? How about in other part of the worlds such as Africa?

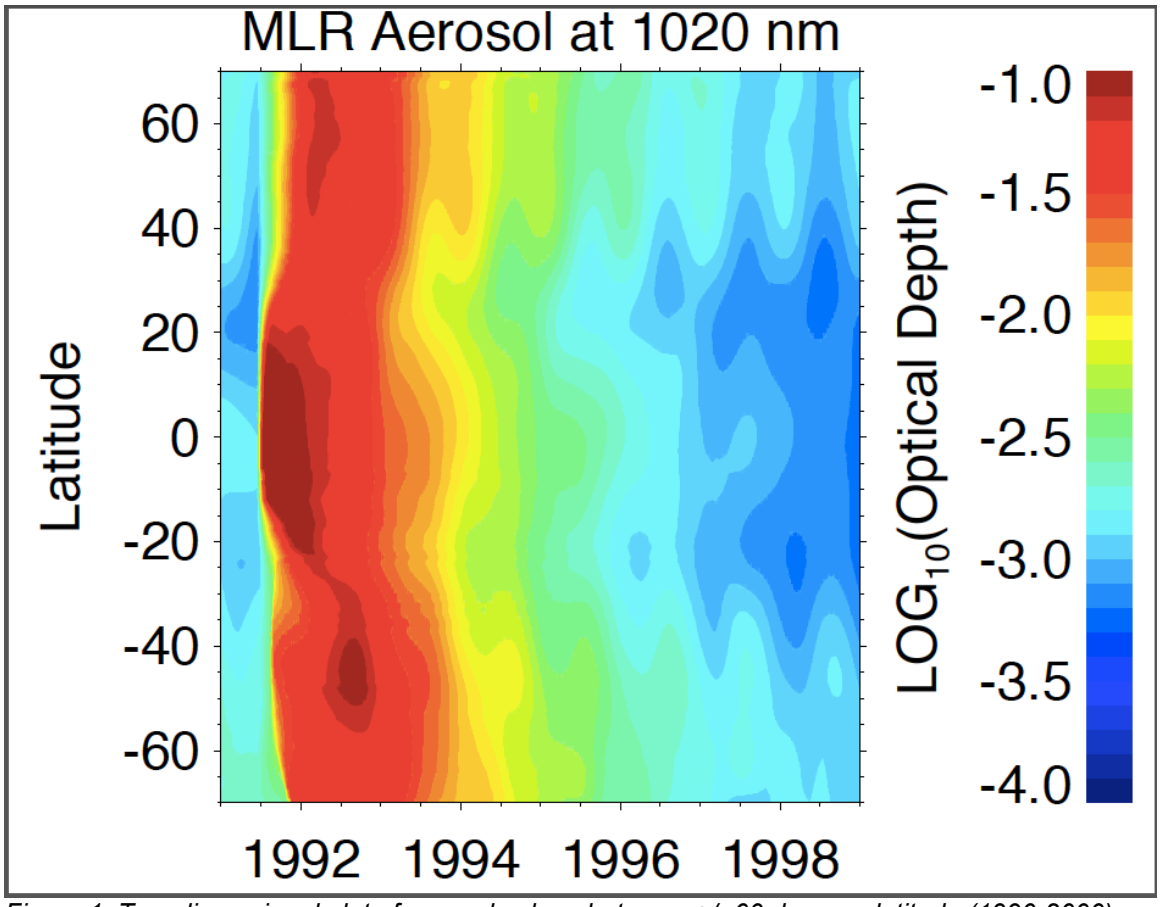

Figure 1: Two-dimensional plot of aerosol values between +/- 60 degrees latitude (1990-2000)

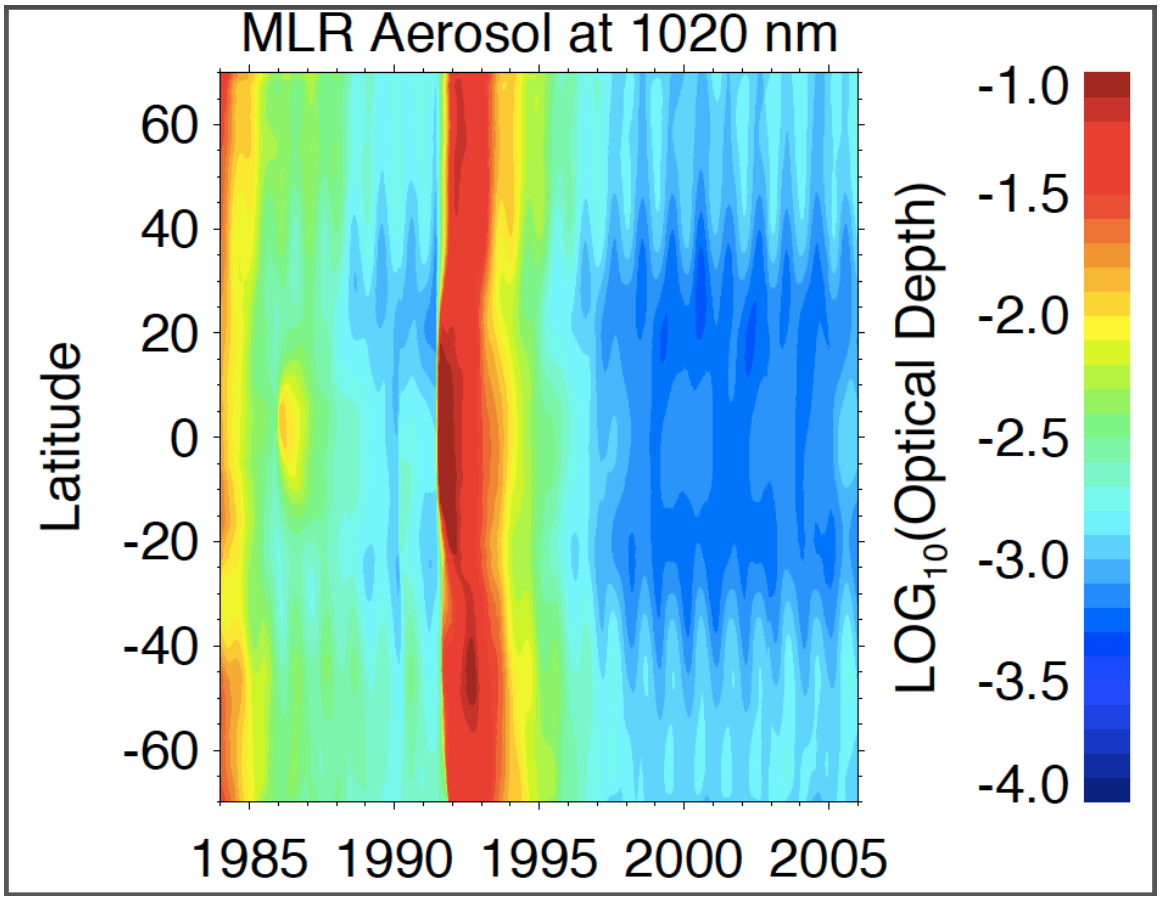

Figure 2: Two-dimensional plot of aerosol values between +/- 60 degrees latitude (1984-2006)